Geophysical Research Abstracts
Vol. 19, EGU2017-17948, 2017
EGU General Assembly 2017

The three-dimensional model of turbulent transfer based on the theory of contrast structures

Natalia Levashova (1), Julia Mukhartova (2), and Alexander Oltchev (3)

(1) Moscow State University, Faculty of Physics, Russian Federation (natasha@npanalytica.ru), (2) Moscow State University, Faculty of Physics, Russian Federation (muhartova@yandex.ru), (3) Moscow State University, Faculty of Geography, Russian Federation, Sevrtsov Institut of Ecology and Evolution, Russian Federation (aoltche@gmail.com)

The description of the air flow interaction with vegetation elements requires adequate parametrization of the energy dissipation within tree crowns. In the study to describe this dissipation we used the theory of contrast structures. Contrast structure (CS) is a function within the domain of which there is some interval with abrupt change in the values of this function. This area is the so-called inner transition layer. The idea to use the CS theory for simulation of the airflow interaction with vegetation came from analysis of the experimental data describing the change of wind velocity at the boundary between two media with different kinematic viscosity (e.g., the forest edge).

A three-dimensional model of turbulent transport was developed using the classical model based on the 1.5 order closures scheme and CS theory. The model consists of a system of six equations: three Reynolds equations for the wind speed components, the continuity equation, the equation for turbulent kinetic energy and the equation for energy dissipation.

The model uses the assumption that the atmospheric surface layer can be considered as a medium that is far from thermodynamic equilibrium or so-called active medium. The main feature of active medium is the ability to be during the long time in one of the possible steady states determined by some external factors. It has a multistable element that can have various possible states and is able to switch from one of these states to another under some external influence. A spatial inhomogeneity within which the energy is dissipated can play the role of such external influence. In the active medium the presence of excitable element that has a single stable state is also possible. If there is a feedback between excitable and multistable elements the switching of multistable element plays the role of external influence on the excitable element. Let us consider the following analogy: the horizontal wind component along some trsansect crossing the forest boundary is a multistable element and it can have two stable states: wind speed in open area and the wind speed inside the forest area far away from the forest edge. Switching of the multistable element occurs due to the energy dissipation in the forest; because of the change of horizontal wind speed component near the boundary of different vegetation types is characterized by some domain with a large gradient. The vertical wind speed component plays the role of the excitable element and has one zero stable state. Feedback is carried out via the continuity equation.

The numerical experiments showed a good agreement of the results obtained using the model based on the theory of the CS and the model of a 1.5 order closure in which the energy dissipation within the vegetation is described using additional term in the corresponding equation. Moreover it was found that for the model based on CS theory the difference schemes are characterized by better numerical stability.

The study was supported by grant of the Russian Science Foundation (14-14- 00956).